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## *Observations of the Planet Jupiter and his Satellites during* 1890 *with the* 12-*inch Equatoreal of the Lick Observatory.* By E. E. Barnard, M.A.

During 1890 I paid considerable attention to observations of *Jupiter*. The planet was observed on forty-nine nights with the 12-inch equatoreal.

Careful observations of transits of the principal markings were obtained and a number of filar micrometer measures of the different spots were made.

Special attention was given to a number of small black spots which were distributed around the planet in north latitude about 13°, and which were placed on the northern edge of the great equatorial belt. In all there were six of these singular objects. At the end of August these had about the following longitudes (referred to Marth's System II.): 41°—104°—213°—258°—327°—352°. They were essentially all on the same parallel of latitude, as shown by the measures of their positions on the disc.

I first saw these spots when observing *Jupiter* on April 26, 1890. They were then quite black and round and about 1″ in diameter, and very much resembled shadows of the satellites. Later, however, they were of a dark reddish colour when best seen. They finally became slightly elongated in the direction of rotation—about 1 : 2. Some of them were intimately associated with a number of very singular reddish spurs or "horse-tails,"

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which jutted out from the northern edge of the equatorial belt and streamed following for some 30°. The black spots were on these horse-tails, and seemed to retain their first positions on them with remarkable constancy—the spot and horse-tail having apparently the same rotation period—which was some ten seconds more rapid than that of the Red Spot. A number of measures were made of the distance between one of these spots and the root of one of the horse-tails, but from observations extending over more than a month no trustworthy change was observed. The matter inside the equatorial belt, however, has a very rapid relative motion.

When first seen two of these small spots were directly north of the Red Spot, and separated from each other by about 8″ or 10″. I have numbered this system of spots 1, 2 . . . 6, beginning with the first of the two directly north of the Red Spot.

The spots in the order of my numbering would roughly have the following longitudes on September 1, 1890:

(1) $\lambda=327°$. (2) $\lambda=352°$. (3) $\lambda=41°$.
(4) $\lambda=104°$. (5) $\lambda=213°$. (6) $\lambda=258°$.

I was curious to know if these objects had any relative motion among themselves, and also to see if there was any change of latitude. Spots 1 and 2 offered a fine opportunity to test these points. I therefore selected them for a series of micrometer measures.

The distance between the two was repeatedly measured throughout the opposition of the planet, and their distances from the south and north limbs of *Jupiter* were also determined. These measures were always made when one or the other of the spots was in transit. I do not think that any actual change of latitude, nor any change in the distance between these spots, is shown. There is, perhaps, a very slight and irregular change in the distance, but probably no more than may be accounted for in the measures themselves. In the latitudes a difference of 1° only represents a discrepancy of 0″·3. An equatorial diameter of 38″·7 was used in deducing the latitudes.

These black spots were nearly all of the same size and appearance. Spot 1 was slightly larger than 2, and 5 was the smallest of all.

There were a number of white spots in the southern hemisphere, principally on a parallel just south of the Red Spot. These were small and round, about 1″ to 2″ in diameter, and very much resembled satellites in transit.

I singled out one of these which was south following the Red Spot, and secured some transits of it. This spot was conspicuous and larger than the average, and had a rather rapid motion with reference to the Red Spot. It and another, some 20° or 30° preceding it, were at the ends of the long dark streak or spot

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which is shown in Mr. Keeler's drawing in *Monthly Notices*, vol. li. No. 1, close south of the Red Spot. This white spot, at first sharply defined and round, gradually dissipated and became diffused and hazy, and was finally lost through extreme dilution, though it was followed until it had completely passed the Red Spot.

My observations of this and of several other white spots in the southern hemisphere lead me to believe that they make their appearance as bright and clearly-defined spots, and that after an ephemeral existence they finally fade and die out like a melting cloud, to which they are probably analogous.

In reference to the long dark spot south of the Red Spot in Mr. Keeler's drawing, it seemed to undergo a transformation in passing the Red Spot. At first it was merely a portion of the dusky region on which the white spots were located, and was hemmed in between the two bright spots just mentioned. It quite rapidly darkened as it approached the Red Spot, and assumed a definite form—that of a short dark streak, tolerably well defined. I am rather inclined to think that this was not the dark spot to which Mr. Williams called attention (*Monthly Notices*, June 1890), for its appearance near the Red Spot was rather sudden, due to the rapid darkening already mentioned. About the time Mr. Williams speaks of seeing his spot I saw a diffused dusky object following the Red Spot, and bridging the bright space just south of the equatorial belt. This must of necessity have passed over or beneath the Red Spot through its motion; when nearing the great spot, however, it rather rapidly diffused, and finally disappeared. It would be interesting if Mr. Williams could settle this point, since the oblong spot still exists, and retains the same latitude it had when passing the Red Spot, though it is now several hours ahead of the latter object. I have given a few observations of transits of this object in Table III. column 11.

In reference to the Great Red Spot, after passing through several years of extreme faintness, it is again assuming the characteristic appearance of the first few years of its existence. During 1890 it had recovered much of its former distinctness, and at the few observations of this year (1891) it is still more distinct. During 1890 the preceding end was always more difficult to observe than the following end, which was better defined. A light cloud seemed to rest over the middle of the Spot.

Following are some measures of the length and position of the Great Spot:—

| 1890. | | | |
|---|---|---|---|
| July 30 | Distance of centre from | south limb | $= 14''.5 = 11''.2$ at $\Delta = 5{\cdot}20$ |
| Oct. 27 | ,, ,, | south limb | $= 11{\cdot}7 = 10{\cdot}9$ at $\Delta = 5{\cdot}20$ |
| Oct. 27 | ,, ,, | north limb | $= 25{\cdot}3 = 23{\cdot}5$ at $\Delta = 5{\cdot}20$ |

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Observations at or close to the time of transit of spot :—

Sept. 14* Length of Red Spot $12''\cdot1 = 10''\cdot0$ at $\Delta = 5\cdot20$
Oct. 27† „ „ $11\cdot4 = 10\cdot6$ at $\Delta = 5\cdot20$

In reference to the discussion that has arisen over the statement that the dark belt south of the Red Spot had overlapped the south part of the Red Spot, I would say that my observations are entirely in accord with Mr. Keeler's beautiful and accurate drawing of *Jupiter* in *Monthly Notices*, vol. li. No. 1.‡

At no time during my observations has any marking on the planet ever overlapped any portion of the Great Spot. In *Publications of the Astronomical Society of the Pacific*, No. 5, p. 91, I have called special attention to this apparent isolation of the Red Spot. It has throughout shown a repulsive force towards the other markings on the planet. At an observation on April 26, 1890, however, the diffused belt south seemed in contact with the south edge of the Red Spot. This perhaps with a small instrument might appear as an overlapping.

Several interesting black transits of the satellites III. and IV. were observed.

1890, August 13. The fourth satellite transited as a black spot, remarkable for its intense blackness. For a full account of this see *Pub. A. S. P.*, No. 10. With first-class seeing and the highest powers the satellite was perfectly round and black.

1890, Sept. 2. The third satellite transited as a black spot. See *Pub. A. S. P.*, No. 11, for a description of this transit.

1890, Sept. 9. The third satellite transited as a black spot. Following are a few notes on this transit.

III. is nearing first contact at transit. It is whiter than any portion of *Jupiter*. Contacts at entrance observed.

Mt. Hamilton M.T. $7^{\mathrm{h}}\ 24^{\mathrm{m}}$ on the disc. Still whiter than any portion of the planet.

$7^{\mathrm{h}}\ 34^{\mathrm{m}}$. Pale now but still distinctly seen.

$7^{\mathrm{h}}\ 37^{\mathrm{m}}$. Just perceptible as a v.v. pale spot.

$7^{\mathrm{h}}\ 41^{\mathrm{m}}$. V.v. faint. There is a *small* dusky speck close following.

$7^{\mathrm{h}}\ 44^{\mathrm{m}}$. It is small and dark.

$7^{\mathrm{h}}\ 49^{\mathrm{m}}$. It is quite dark and very small.

$7^{\mathrm{h}}\ 56^{\mathrm{m}}$. The satellite is black. It is a little smaller than either of the two black spots (1 and 2).

$9^{\mathrm{h}}\ 34^{\mathrm{m}}$. It is still very dark, but it has not been as black as was IV. at the transit of Aug. 13. It is larger and blacker than either of the small spots.

1891, Nov. 27. When three-quarters across the disc the third satellite was very dark. Later, when off the disc, it appeared less than the other satellites.

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* Measured at $7^{\mathrm{h}}\ 17^{\mathrm{m}}$. † Measured at transit of *p* end.

‡ Mr. Keeler's drawings should receive the very highest weight, as he has a real artistic ability such as very few observers possess.

I send a series of sketches of the appearances of Satellite IV. when emerging from transit 1890, Aug. 13 (Plate 14, fig. 3).

On this occasion as the satellite emerged it seemed to leave behind it a small dark spot which apparently remained stationary and diminished in size, as the satellite receded, until it became lost through exceeding smallness.

In connection with the black transits of III. and IV. I have often seen I. transiting as a dark or dusky spot. On Sept. 8, 1890, with the 12-inch this satellite presented a remarkable aspect while in dark transit. I noticed that it appeared elongated in a direction nearly perpendicular to the belts of *Jupiter*.

With high powers (500 and 700) and perfect definition the satellite appeared distinctly double, the components clearly separated. At my request Mr. Burnham kindly examined the satellite with me, and we both distinctly saw the phenomenon of apparent duplicity (see *Ast. Nach.* 2995). In reference to the *appearance* of the satellite—whatever may be the explanation—Mr. Burnham has no hesitation in stating that it was as distinctly double as any double star that he has seen. The distance between the centres of the two images was about 1″, and the position angle at transit 173°±. The south component was very slightly the smaller (Plate 14, fig. 4). It was not possible to follow the satellite closely, because of interruption by a number of visitors, and the great telescope was not available for observing the phenomenon.

I have offered two explanations of this phenomenon (*A.N.* 2995).

1st. That the satellite had a white belt on it parallel to those of *Jupiter*, or

2nd. That the satellite is actually double. I do not now think that the first of these theories is satisfactory, as it would require a far whiter belt than we have reason to believe will exist on the satellite, reasoning from our knowledge of the phenomena of *Jupiter* itself. I am strongly inclined to favour the theory of actual duplicity.

It may be asked, If the satellite is double why has it not so been seen when projected on the sky, if the distance is as much as one second? In the case of two stars this distance would be very easy with any considerable telescope. We must remember, however, that in the case of a double satellite we should have two sensible discs, which would perhaps never be well enough defined to show a maximum separation of only one second, while the greater part of the time the distance would be much less than this. If, however, the satellite were projected on a background brighter than itself it would appear reduced to its minimum size, so that if duplicity existed the chances for detecting it would be far more favourable. To better illustrate my meaning: Mercury is a very brilliant object to the naked eye about the

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times of its greatest elongation. Yet when this planet crosses the Sun it is shorn of its light and cannot be seen with the unaided eye, though it is then a fifth nearer to us. On this same principle if the satellite consists of two moons the largeness of their ill-defined discs would make them appear as one in a telescope. Transferred, however, to a bright surface, the confusing light is got rid of and the size of the object is reduced to a minimum, and if double then will be the most favourable time to detect it.

If this satellite is really double, the components at the time of my observation were probably at their greatest elongation. If so this would indicate a distance from centre to centre of some 2,000 miles. The individual components would be about 1,000 miles in diameter, and their orbits nearly perpendicular to that of *Jupiter*, with a period of revolution of a few hours.

I trust that this satellite at its transits this year will receive the closest attention with powerful telescopes. It should be examined with the highest powers, and the direction of elongation, if any, carefully noted. If double, I have not much hope of the components ever being seen when projected on the sky.

In reference to the abnormal or black transits of the third and fourth satellites, from an experience of many years in actually observing the phenomenon I should feel much hesitation in endorsing the theory that they are due alone to contrast. I have seen these satellites cross the same regions of *Jupiter's* disc in bright transit and again like drops of ink. Assuming the albedo of the satellite to be approximately constant, that of *Jupiter* would need to vary so vastly that it must rank as a variable star.

In speaking upon this matter Mr. John Tebbutt, in *Pub. A. S. P.*, makes a statement that is certainly not upheld by observation. He says, " Further, a dark phase does not take place when the satellite crosses the polar regions of the planet." In *Pub. A. S. P.*, No. 5, pp. 108, 109, I have given a series of observations of the phenomena of *Jupiter* and his satellites, made with a 5-inch refractor at Nashville, Tenn., from which I quote—

" 1880, December 30, $8^h\ 30^m$. Satellite III. seen in a high south latitude as a small black spot; continued visible as a black spot until near p. limb, and only lost its blackness at $9^h\ 4^m$."

" 1886, May 8, $9^h\ 20^m$. Satellite IV. near north pole; very black."

Perhaps there would be no trouble in finding other instances where the satellites have been seen black in the polar regions.

I have never been able, in twelve years' time, to witness the phenomenon of a satellite shining through the limb of *Jupiter*—*i.e.* visible through the planet after the satellite had disappeared behind it in occultation. I have carefully watched a number of occultations with this subject specially in view, but, though the seeing on many of these occasions was perfect, no trace of any

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of the satellites could ever be seen after the last contact at occultation. I have, therefore, come to the conclusion that this phenomenon, which has been reported by several observers, is exceedingly rare, or it is wholly beyond the reach of a first-class 5- or 12-inch telescope.

In the drawing of *Jupiter* for July 30, 1890 (Plate 14, fig. 1), I have given a careful delineation of the principal markings. Under favourable circumstances there is always such a vast amount of fine detail shown on the planet with the 12-inch that an accurate representation of it all is quite hopeless. On this drawing are shown three of the small black spots, Nos. 1, 2, and 3. Later in the same night I have given a more detailed drawing (Plate 14, fig. 2) of the equatorial belt and its appendages—the "horse-tails." This also shows spots 3 and 4, and their relation to the "horse-tails."

In the following tables are the observations and measures. They need but very slight explanation.

In Table I. Δ S.P. and Δ N.P. are the apparent distances of the satellites from the south and north limbs of *Jupiter*. "Time for Δ" in the last column gives the time of the measures of the satellites' position.

In Table II. Obs. Δ (I.–II.) is the value by direct measurement of the distance between spots 1 and 2; while 5·20 Δ (I.–II.) is the same quantity reduced to distance 5·20; so also for the quantities Δ N.P. and Δ S.P., which are the values for the distances from the north and south limbs. ♃ $\beta$ are the Jovicentric latitudes as derived from the measures, and which have been corrected for the elevation of the earth above *Jupiter's* equator by the aid of Mr. Marth's invaluable ephemeris. In the ninth column is given the number of the observed spot.

In Table III. P, M, F are the preceding end, middle, and following end of the Red Spot. Column 11 contains the observation of the oblong dusky spot shown close south of Red Spot in Mr. Keeler's drawing. The white spot in column 12 was at the following end of the dusky spot just mentioned. The measurements of the positions of the small black spots were derived from two to three settings of the wires. Although they were usually very conspicuous, it was found that they were quite ill-defined and rather difficult when the wires were placed over them.

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## OBSERVATIONS OF THE SATELLITES.

*Mount Hamilton Mean Time.*

TABLE I.

| Date. 1890. | Satellite. | First Cont. h m s | Bisection. h m s | Last Cont. h m s | Mid. Tran. h m | Δ S.P. ″ | Δ N.P. ″ | Time for Δ. h m |
|---|---|---|---|---|---|---|---|---|
| April 26 | III. Tr. Egr. | 16 3 27 | 16 6 7 | 16 8 56 | | | | |
| July 8 | I. Tr. Egr. | 11 10 4 | 11 12 1 | 11 13 9 | | | | |
| 30 | I. Oc. Imm. | 11 22 39 | 11 24 59 | 11 26 0 | | | | |
| Aug. 13 | IV. Sh. Ing. | 10 57 8 | 10 59 3 | 11 3 32 | | | | |
| 13 | IV. Tr. Egr. | ... | 12 4 30 | ... | 9 42·2 | 28·4 | 18·2 | 10 21 |
| 22 | III. Oc. Imm. | ... | 10 45 8 | 10 48 43 | | | | |
| 28 | II. Oc. Imm. | 9 35 28 | 9 37 12 | 9 38 36 | | | | |
| 31 | I. Oc. Imm. | 7 6 39 | 7 17 54 | | | | | |
| Sept. 1 | I. Sh. Tr. Egr. | 7 25 15 | 7 26 37 | 7 28 47 | | | | |
| 2 | III. Sh. Ing. | ... | 7 7 9 | 7 11 7 | | | | |
| 2 | III. Tr. Egr. | 7 18 15 | 7 21 5 | 7 25 55 | ... | 26·0 | 19·7 | 6 52 |
| 8 | I. Tr. | ... | ... | ... | 7 24·7 | 21·9 | 22·8 | 7 33 |
| 9 | III. Tr. Ing. | 7 17 20 | 7 19 59 | 7 22 24 | 9 1·9 | 25·2 | 19·4 | 8 18 |
| Oct. 27 | IV. Oct. Imm. | 7 15 4 | 7 18 49 | 7 21 48 | | | | |
| Nov. 20 | III. Sh. Imm. | ... | 6 52 5 | ... | | | | |
| 1891. July 4 | I. Tr. Egr. | ... | 13 26 56 | ... | | | | |

July 8.—The times a little uncertain. Aug. 13.—Black transit of IV. Sept. 2.—Black transit of III. Sept. 8.—I. apparently double. Sept. 9—Black transit of III.

### *Micrometer Measures of the Small Dark Spots.*

TABLE II.

| | Obs. Δ(I.–II.) | 5·20 Δ(I.–II.) | Obs. ΔS.P. | 5·20 ΔS.P. | Obs. ΔN.P. | 5·20 ΔN.P. | ♃β. | Spot. |
|---|---|---|---|---|---|---|---|---|
| 1890. | ″ | ″ | ″ | ″ | ″ | ″ | ° | |
| July 30 | ... | ... | 29·6 | 23·2 | 17·2 | 13·5 | +13·7 | 1 2 |
| Aug. 1 | ... | ... | 29·6 | 23·2 | 17·2 | 13·5 | +13·7 | 1·2 |
| | 10·4 | 8·2 | ... | ... | ... | ... | ... | 1·2 |
| 11 | 10·3 | 8·1 | 29·2 | 22·9 | 16·7 | 13·1 | +13·9 | 6 |
| 13 | ... | ... | 28·4 | 22·4 | 18·2 | 14·3 | +11·3 | 1·2 |
| 18 | 9·9 | 7·8 | 28·3 | 22·4 | 19·0 | 15·1 | +10·3 | 1·2 |
| 25 | 10·5 | 8·4 | 29·6 | 23·7 | 17·4 | 13·9 | +13·5 | 1·2 |
| 26 | ... | ... | 28·6 | 22·9 | 17·5 | 14·0 | +12·5 | 3 |
| 28 | 9·6 | 7·7 | ... | ... | ... | ... | ... | 1·2 |
| Sept. 5 | ... | ... | 29·2 | 23·8 | 18·2 | 14·8 | +12·6 | 4 |
| 14 | 8·2 | 6·9 | ... | ... | ... | ... | ... | 1·2 |
| 21 | 8·6 | 7·4 | 27·6 | 23·7 | 16·9 | 14·5 | +12·9 | 1·2 |
| Oct. 12 | 7·5 | 6·9 | 25·3 | 23·1 | 15·5 | 14·1 | +12·6 | 1·2 |
| 20 | 7·4 | 6·9 | 24·2 | 22·5 | 15·5 | 14·5 | +11·3 | 1·2 |
| 26 | ... | ... | 24·1 | 22·9 | 14·2 | 13·5 | +13·2 | 5 |
| 27 | 7·6 | 7·3 | 24·2 | 23·2 | 14·1 | 13·5 | +13·8 | 1·2 |
| Nov. 20 | 7·8 | 8·0 | 24·0 | 24·5 | 12·9 | 13·2 | +14·6 | 1·2 |
| 1891. | | | | | | | | |
| May 14 | 8·0 | 8·2 | 21·5 | 22·1 | 14·2 | 14·6 | +12·2 | 1·2 |
| July 4 | 7·4 | 6·4 | 25·6 | 22·1 | 15·9 | 13·7 | +13·9 | 1·2 |

The above measures were made at the time of the objects' central transit.

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*Mount Hamilton Mean Time of Observed Transits of Spots.*

TABLE III.

| | Red Spot. | | | Small Black Spots. | | | | | | Oblong Spot. | White Spot. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | M | F | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 1890. | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m |
| April 26 | 15 49·3 | 16 0·7 | 16 23·2 | 15 53·2 | | | | | | | |
| July 8 | ... | 11 16·3 | 11 38·3 | ... | 11 20·3 | | | | | | |
| 13 | ... | ... | ... | ... | ... | 11 55·5 | | | | | |
| 14 | ... | ... | ... | ... | ... | ... | 12 30·4 | | | | |
| 15 | ... | 12 9·5 | 12 29·5 | ... | 12 13·0 | 13 37·3 | | | | | |
| 30 | ... | 9 22·9 | 9 48 8 | ... | 9 35·8 | 10 48·6 | ... | ... | ... | ... | 10 11·2 |
| Aug. 1 | 10 36·6 | 11 1·0 | 11 23·4 | 10 17·6 | 11 3·0 | ... | ... | ... | ... | ... | 11 47·9 |
| 2 | ... | ... | ... | ... | ... | 9 42·9 | | | | | |
| 6 | ... | ... | ... | ... | ... | 11 30·6 | ... | ... | ... | ... | 10 59·2 |
| 8 | ... | ... | ... | 11 3·8 | | | | | | | |
| 11 | ... | ... | ... | 8 32·4 | ... | ... | ... | ... | ... | ... | 9 58·0 |
| 13 | ... | 11 ·5 | ... | ... | 11 1·0 | | | | | | |
| 17 | ... | ... | ... | ... | ... | ... | ... | ... | 1 29·0 | | |
| 18 | 9 37·9 | 10 2·4 | 10 25·3 | ... | 10 0·9 | ... | ... | ... | ... | ... | 10 32·3 |
| 21 | ... | ... | ... | ... | ... | 8 43·2 | | | | | |
| 25 | ... | 10 40·5 | ... | 9 58·0 | 10 39·5 | | | | | | |
| 26 | ... | ... | ... | ... | ... | 7 52·1 | 9 37 | | | | |

| | Red Spot. | | | Small Black Spots. | | | | | | Oblong Spot. | White Spot. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | M | F | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 1890. | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m | h m |
| Aug. 28 | 7 52·0 | 8 10·4 | ... | ... | 8 8·9 | | | | | | |
| Sept. 1 | ... | ... | ... | ... | ... | ... | 7 35·3 | | | | |
| 2 | ... | 7 26·3 | ... | ... | 7 18·0 | | | | | | |
| 5 | ... | ... | ... | ... | ... | ... | 7 39·7 | | | | |
| 9 | ... | 8 6·7 | ... | 7 19·9 | | | | | | | |
| 11 | ... | ... | ... | ... | ... | 10 57 | ... | 7 6·5 | | | |
| 14 | 6 55·5 | ±7 17·4 | 7 42·3 | ... | 7 5·5 | | | | | | |
| 21 | ... | 8 10·1 | 8 35·0 | 7 17·2 | 7 51·1 | | | | | | |
| Oct. 12 | ... | ... | ... | ... | 10 5·3 | ... | ... | ... | ... | ... | 10 5· |
| 20 | ... | 7 8·6 | ... | ... | 6 45·2 | | | | | | |
| 26 | ... | ... | ... | ... | ... | ... | 7 54·6 | | | | |
| 27 | 7 33·8 | 7 56·6 | ... | 6 50·9 | 7 33·8 | | | | | | |
| 28 | ... | ... | ... | ... | ... | ... | 6 16·0 | | | | |
| 29 | ... | ... | ... | 8 31·0 | ... | ... | 6 47·0 | ... | .. | 6 53·4 | |
| Nov. 20 | ... | ... | ... | 6 41·3 | | | | | | | |
| 1891. | | | | | | | | | | | |
| June 5 | ... | 16 27·3 | | | | | | | | | |
| July 4 | ... | ... | ... | 12 33 | | | | | | | |

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*Longitudes of Spots, Referred to Marth's System II.*

TABLE IV.

| Date. | Red Spot. | | | Small Black Spots. | | | | | | Oblong Spot. | White Spot. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | M | F | 1 | 2 | 3 | 4 | 5 | | | |
| 1890. | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| April 26 | 346·0 | 352·9 | 6·5 | 348·4 | | | | | | | |
| July 8 | ... | 355·5 | 8·8 | ... | 257·9 | | | | | | |
| 13 | ... | ... | ... | ... | ... | 51·2 | | | | | |
| 14 | ... | ... | ... | ... | ... | ... | ... | 222·9 | | | |
| 15 | ... | 360·5 | 12·6 | ... | 364·7 | 53·6 | | | | | |
| 30 | ... | 355·9 | 11·5 | ... | 363·7 | 47·7 | ... | ... | ... | ... | 25·1 |
| Aug. 1 | 341·3 | 356·0 | 9·5 | 329·8 | 357·2 | ... | ... | ... | ... | ... | 24·2 |
| 2 | ... | ... | ... | ... | ... | ... | ... | ... | 260·9 | | |
| 6 | ... | ... | ... | ... | ... | 45·8 | ... | ... | ... | ... | 26·9 |
| 8 | ... | ... | ... | 330·5 | | | | | | | |
| 11 | ... | ... | ... | 330·0 | ... | ... | ... | ... | ... | ... | 21·7 |
| 13 | ... | 361·5 | ... | ... | 360·6 | | | | | | |
| 17 | ... | ... | ... | ... | ... | ... | ... | ... | 359·1 | | |
| 18 | 342·2 | 357·0 | 10·7 | ... | 356·1 | ... | ... | ... | ... | ... | 15·0 |
| 21 | ... | ... | ... | ... | ... | 40·0 | | | | | |
| 25 | ... | 352·3 | ... | 326·7 | 351·7 | | | | | | |
| 26 | ... | ... | ... | ... | ... | 40·8 | 104·2 | | | | |
| 28 | 341·5 | 352·6 | ... | ... | 351·6 | | | | | | |

| Date. | Red Spot. | | | Small Black Spots. | | | | | | Oblong Spot. | White Spot. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | M | F | 1 | 2 | 3 | 4 | | | | |
| 1890. | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| Sept. 1 | ... | ... | ... | ... | ... | ... | ... | 212·7 | | | |
| 2 | ... | 357·4 | ... | ... | 352·4 | | | | | | |
| 5 | ... | ... | ... | ... | ... | ... | 96·3 | | | | |
| 9 | ... | 353·9 | ... | 325·6 | | | | | | | |
| 11 | ... | ... | ... | ... | ... | 37·3 | ... | ... | 258·0 | | |
| 14 | 342·0 | 355·2 | 10·3 | ... | 348·0 | | | | | | |
| 21 | ... | 358·8 | 13·7 | 326·8 | 347·4 | | | | | | |
| Oct. 12 | ... | 356·5 | ... | ... | 342·2 | ... | ... | ... | ... | ... | 342·2 |
| 20 | ... | 356·5 | ... | ... | 342·3 | | | | | | |
| 26 | ... | ... | ... | ... | ... | ... | ... | 205·0 | | | |
| 27 | 342·4 | 356·2 | ... | 316·5 | 342·4 | | | | | | |
| 28 | ... | ... | ... | ... | ... | ... | 85·4 | | | | |
| 29 | ... | ... | ... | 317·4 | ... | ... | ... | ... | 354·4 | 258·3 | |
| Nov. 20 | ... | ... | ... | 314·5 | | | | | | | |
| 23 | ... | 357·8 | | | | | | | | | |
| 1891. | | | | | | | | | | | |
| June 5 | ... | 3·1 | | | | | | | | | |
| July 4 | ... | ... | ... | 260·1 | | | | | | | |

Oct. 12. Perhaps the white spot observed is not the one previously noted. The transit refers to a white spot on the parallel of the one observed before. It was on the same meridian with spot 2.

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## *Note on the First Satellite of Jupiter.* By E. E. Barnard, M.A.

In reference to my previous remarks on the apparent duplicity of this satellite, I would state that it now transits in front of the dark south equatorial belt, and therefore does not appear dark in transit, being very nearly the same depth of shade as the belt when in mid-transit. Before these dark transits can again be observed the satellite's apparent latitude must increase considerably to shift it on to the bright surface of the planet south of the equatorial belt. This will not occur before the opposition of 1892.

I have been carefully watching the satellite, however, with the 12-in. when in transit as a bright spot, before it reaches the point of disappearance.

On August 3 I examined it thus, with the 36-inch refractor, when it appeared as an elongated white spot, the preceding end of which was the smaller. Under the best definition, with 700 diameters, this elongation was decidedly noticeable, and in moments of extra definition I suspected a line of separation; but this I could not be sure of. If the satellite actually consisted of two bodies the distance between their centres could scarcely have exceeded $0''\cdot2$.

The angle of position was estimated to be 265°± referred to the following end.

"At $13^h\ 0^m$ (Mt. H. M.T.) Satellite I. is surely much elongated—nearly parallel to the belts. Its shadow is large and round."

"$13^h\ 17^m$. There is no hesitation as to I. being elongated. Occasionally I think there are two; if so, the smaller one is preceding."

Shortly after this the satellite was lost or only faintly visible. Expecting to be able to catch it when leaving the disc, I turned to the east and observed Encke's Comet. Before the dome could be again turned to the south the satellite had just emerged. The definition then was not such as to give any information as to the form of the disc.

Satellite II. was carefully watched as it transited, preceding I. It appeared perfectly round until it wholly disappeared on the belt. *This was during the time that I. appeared elongated.*

*Mount Hamilton:*
1891 *August* 4.